The Viotropic Wall: Finite Capacity, Thermodynamic Calibration, and the Limits of Local Inference

Inacio F. Vasquez

January 2026

Abstract

Recent critiques of machine reasoning systems emphasize a recurring phenomenon: increasing internal complexity does not translate into improved global understanding. We formalize this observation as a universal rigidity principle. Under three axioms—finite transcript capacity, thermodynamic calibration, and informational monotonicity—we prove the existence of a sharp boundary, the *Viotropic Wall*, beyond which additional internal structure becomes operationally invisible to any local observer. The result applies uniformly across computational, physical, and biological inference systems and yields a diagnostic protocol (IC3) for detecting regime violations.

1 Introduction and Motivation

Local inference dominates modern science: algorithms refine hypotheses through partial observations, physical instruments sample systems through bounded interfaces, and biological agents adapt via limited sensory channels. Yet in each domain the same obstruction appears: certain global structures cannot be reliably inferred regardless of internal sophistication.

In finite model theory this manifests as locality theorems and bounded-variable logics. In computation it appears as transcript and memory bounds. In physics it is enforced by thermodynamic limits on information flow. This paper isolates the common invariant underlying these phenomena.

2 Interfaces and Transcripts

Definition 1 (Interface)**.** *An interface mediates interaction between an unknown system state X and an observer, producing a transcript $Y_{1:T}$ via admissible observation rules.*

Definition 2 (Transcript Capacity)**.** *The transcript capacity of an interface over horizon T is*

$$TC(T) := \sup I(X; Y_{1:T}).$$

3 Axioms

Assumption 1 (Finite Capacity (FC))**.** *For any declared admissible regime, $TC(T) < \infty$ and $TC(T) = O(T)$.*

Assumption 2 (Landauer Calibration)**.** *If the interface dissipates heat at rate $\dot{Q}(t)$ at temperature Θ, then*

$$TC(T) \leq \frac{1}{k_B \Theta \ln 2} \int_0^T \dot{Q}(t)\, dt.$$

Assumption 3 (Informational Monotonicity (Mon))**.** *For any admissible observer,*

$$H_{\text{extractable}} \leq TC(T).$$

4 The Viotropic Wall

Definition 3 (Operational Mutual Information)**.** *For any observable O derived from an admissible transcript, define*

$$I_{\text{op}}(X; O) := H(O) - H(O \mid X).$$

Theorem 1 (Viotropic Wall)**.** *There exists $\kappa > 0$ such that for any admissible regime,*

$$\mathrm{Dem}_\eta(T) > \kappa \cdot TC(T) \quad \Longrightarrow \quad I_{\text{op}}(X; O) = 0.$$

Proof. By Informational Monotonicity, $H_{\text{extractable}} \leq TC(T)$. If $\mathrm{Dem}_\eta(T) > \kappa TC(T)$, then no admissible transcript can encode sufficient information to resolve X to accuracy η. Any observable O derived from the transcript is therefore statistically independent of X, yielding $I_{\text{op}}(X; O) = 0$. □

5 IC3 Diagnostic Protocol

We define the *Information–Capacity Calorimeter* (IC3) as a forensic test of admissibility:

1. Measure empirical $TC(\tilde{T})$ from transcript statistics.
2. Measure thermodynamic capacity $TC_{\text{therm}}(T)$ from heat dissipation.
3. Enforce monotonicity: $H_{\text{extractable}} \leq TC(\tilde{T})$.
4. Test demand: $\mathrm{Dem}_\eta(T) > \kappa TC(\tilde{T})$.
5. Probe outcome: estimate $I_{\text{op}}(X; O)$.

If $I_{\text{op}} > 0$ under steps (1)–(4), a regime exit is certified.

6 Discussion

The Viotropic Wall is an informational event horizon. Beyond it, internal structure may exist but cannot influence any admissible observation. The principle unifies locality theorems in logic, transcript bounds in computation, and entropy limits in physics.

7 Conclusion

Under minimal and physically interpretable axioms, global inference is sharply bounded. Over-demanded information is not merely noisy; it is operationally extinct.

References

[1] L. Libkin, *Elements of Finite Model Theory*, Springer, 2004.

[2] N. Immerman, *Descriptive Complexity*, Springer, 1999.

[3] T. Cover and J. Thomas, *Elements of Information Theory*, Wiley, 2006.

[4] R. Landauer, Irreversibility and heat generation in the computing process, *IBM Journal of Research and Development* 5 (1961).